Working Meeting to Address HIPPI-6400 Issues Only
Monday and Tuesday, June 10-11, 1996
Santa Fe, NM

1. Opening remarks and introductions

The Chairman, Don Tolmie of Los Alamos National Laboratory, opened this HIPPI-6400 meeting and accepted thanks from the group for Los Alamos National Laboratory, and himself, hosting this meeting. This group is constituted as both the HIPPI special working group (SWG) under X3T11, and the HIPPI Networking Forum (HNF) - Technical Committee (TC).

Don then lead a round of introductions. The list of attendees is at the end of these minutes.

2. Review / modify the draft agenda

The draft agenda on the web was updated with the inclusion of item 3 – review of the minutes and action items. IBM requested time to present some issues concerning the 4b/5b coding, and item 4.1a was added to the agenda. These minutes reflect the approved agenda.

3. Review minutes of previous meetings

3.1 May 9-10, Dallas

The minutes were reviewed. Joe Parker of Optivision moved, and Greg Chesson of SGI seconded, to approve the minutes as written. Passed unanimously.

3.2 May 22, Albuquerque

A minimal set of minutes were prepared for this meeting, with the main result being the HIPPI-6400-PH document changes regarding the header micropacket contents. Roger Ronald of E-Systems moved, and Joe Parker of Optivision seconded, to approve the minutes as written. Passed unanimously.

3.3 Review action items from Dallas meeting

1. Stan Swirhun, and others, to consider problems with FRAME signal frequency in optical implementations. (Carryover)
2. Greg Chesson and Jim Pinkerton to merge the MPI and Schedule headers and propose a general micropacket header. (Done at Albuquerque meeting)
3. Don Tolmie to make copper guidelines available via e-mail. (Done, albeit fairly late)
4. Don Tolmie to submit a rewrite of section HIPPI-6400-PH 6.6 via e-mail. (Not done, proposed changes included in rev 0.25)
5. Greg Chesson to provide Don Tolmie with the parallel CRC equations to be added as an annex. (Carryover)
6. James Hoffman to verify CRC error protection results. (Carryover)
7. Greg Chesson to gather SGI header ideas to be used at the May 22 meeting. (Done)
8. Roger Ronald to draft an annex on micropacket interleaving to be reviewed via e-mail. (Done)
9. Roger Ronald to present a proposal for alternate pathing to e-mail. (Done)
10. Roger Ronald to define admin micropacket contents and requirements and present to e-mail. (Carryover)
11. Henry Brandt to inform and invite various optical and copper companies to the Santa Fe meeting. (Done)
12. Roger Ronald to update HIPPI-6400-SC Rev 0.10 with changes agreed to at this meeting. (Done)
13. Don Tolmie to update HIPPI-6400-PH Rev 0.21 with changes agreed to at this meeting and incorporating details from the SuMAC specification. (Done)
14. Greg Chesson to put out a meeting notice for the July meeting at SGI via e-mail. (Done)
15. Michael McGowen to put out a meeting notice for the May 22 meeting at Essential via e-mail. (Done)

4. Review HIPPI-6400-PH changes since last meeting (Reference Rev 0.25)

4.1 Minor changes first and then return to the more detailed ones

Last two bullets in the Introduction - accepted.

Definition for "Final Destination" - accepted.

Definition for "Originating Source" - accepted.

Definition for "scheduled transfer" - accepted with some wording changes.

Definition for "syndrome" - accepted.

New figure 1 - changed bold boxes to normal for HIPPI-800 Node and Gigabit Ethernet Node, added bold boxes at the top of the Translation Function.

Changes to Figure 2 - accepted.

Changes to last sentence of 4.3 - accepted.

Changes to first sentence of 4.4 - accepted.

Change Figure 4 with "Header information" - accepted.

Change to first sentence of 4.7 - accepted.

Changes to last two paragraphs of 4.8 - accepted.

Changes to Table 1 re "c00 - c47" - accepted.

Changes to last sentence of third paragraph of 6.1 - accepted.

Last sentence of note below figure 7 - accepted.

Last sentence describing VC1 and VC2 in 6.2 - accepted.

Addition to 6.3 describing actions on unspecified TYPE codes - agreed to change values to hex notation, and add a note about allowing for future expansion.

Changes to table 2 body - accepted.

Changes to table 2 notes - accepted.

Addition of note 3 in 6.5 - accepted.

Changed first few words of 8.4 - accepted.

Changed note 4 in tables 6 and 7 - accepted.

Changed disparity to 0 ± 1 in figures 12 and 13, and in the text following - agreed to change to 0 or -1.

Added last 1/2 sentence in 14.1 - accepted.

Added text in 14.3 - accepted.

Changed figure B.1 to show serial stream - accepted.

4.1a 4b/5b Coding Problems

Al Widmer, of IBM T.J. Watson Research Center, described how a low frequency component could occur in our 4b/5b code. For example, if the disparity goes from some minus number to -1, and then goes more negative on the next code, and repeats this for several cycles; then does the same type of thing on the positive disparity side. The result is a waveform that may contain frequency components as low as 310 KHz.

Al also stated that if the 8b/10b code was used, then the CLOCK and FRAME signals could be derived from the other signals and would not have to be transmitted on separate signal lines. Greg Chesson allowed how this was possible, but pointed out the difficulty of putting PLLs on the chip.

Al compared the 4b/5b code to the 8b/10b code used in Fibre Channel, showing advantages for the 8b/10b coding in shorter run lengths and a narrower frequency range. For comparison, the 4b/5b passband was seven times greater than the 8b/10b passband. Greg Chesson said that while the 8b/10b code may have better frequency characteristics, it also requires many more gates to implement. Al countered by saying that coding and decoding circuits could be multiplexed, e.g., use one coder for several bit lines.

The attendees were unsure how significant the problem was, i.e., is the wide frequency range a problem with real transmission lines, and how many gates are required to implement 8b/10b.

Greg Chesson took an action item to check the number of gates required to implement 8b/10b.

Greg Chesson and James Hoffman took an action item to check the low frequency component of the 4b/5b code.

4.2 CRCs and LCRC (pages 11-12)

The first two paragraphs of 6.6.1 had been extensively changed. An addition to point out that "other documents may require intermediate devices to pass the ECRC unchanged" was agreed to.

What had incorrectly been in the document as the ECRC was moved to the LCRC. The initial seed was changed from "all ones" to x'FFFF', and the polynomial corrected. The bits in figure 8 were renumbered. All of these changes were accepted as written.

The 'stomp code' was added, and reviewed. It was agreed to re-word the second paragraph about the stomp code, pointing out that it was just the logging that was different between the syndrome being non-zero or equaling the stomp code. The notes will also be expanded to note that the stomp code is an error isolation mechanism.

In 6.6.3, a few editorial changes were made in the first paragraph, and in note 2. The ECRC polynomial was changed. It was suggested that a figure showing the ECRC implementation (like the LCRC in figure 8) be included even though we have not yet fully agreed on the ECRC polynomial.

4.3 ACK and retransmissions (page 21-22, and 23)

There were some wording changes; mostly editorial. The ACK timeout default value text will be changed to note that it can be set to a smaller value, but that is outside the scope of the standard.

The default value for successive retransmissions was changed from three to two. It was agreed that shutdown is based on the number of times the Source retries, not the number of micropackets retransmitted; and the number of "consecutive" retries, not the total number of retries.

There were some editorial changes agreed to for 9.2, but no major technical changes were made.

4.4 Initialization and resets (pages 29-30)

All of the text in 12, and its subclauses, was new. Don had tried to base the text on what was in the SuMAC specification. In the interest of clarity, it was agreed to do a global change of "Reset" to "Link Reset". Other editorial changes were agreed to.

In 12.3, the case of a link not coming out of Reset, and triggering a link shutdown, will be added.

The Initialize and Link Reset operation flow diagram in figure 14 was reviewed. It was agreed that we could remove the 10 second line-charge time and let correct micropacket reception be the indicator that the line was operating correctly.

Greg Chesson took an action item to provide text describing shutdown actions.

Greg Chesson took an action item to check the initial pattern for Reset operations and the need for the 10 second line-charge time.

4.5 Checking for errors (page 22-23)

All of 9.1 was new. Don tried to base it on what was in the SuMAC specification. After reviewing the text, it was agreed that the strict ordering of the tests was probably too specific, and it should be broken into two groups, i.e., the CRCs tested in one group, and everything else in the second group. Some editorial changes were suggested.

In item "k", the timer will be noted as programmable with a default value (no value was picked). Using a new "TYPE" for the fabricated Tail was suggested, and will be included as an open issue. We also need to define what "logging" is. Rather than being optional, it was agreed to make logging mandatory and include a list of names and field lengths for the logged parameters.

4.6 Header micropackets contents (pages 12-14)

All of 6.7, and its subclauses, was new. Don, with major help from James Hoffman, tried to base it on what was agreed to at the Albuquerque meeting. A problem was that changes were suggested after the Albuquerque meeting, and may not be accurately represented. At least there was text on paper that we could argue about.

It was agreed that the second micropacket of a message will always have TYPE = Data even if it contains header information. In a major change, the ECRC accumulation was changed to include the first micropacket. (Starting at the second micropacket had been used on the assumption that the header could change in the fabric, but this is no longer true.)

It was agreed that information in the Transtype field would be used to identify the valid header fields in the message. It was agreed that the M-len parameter would denote the number of bytes following the first micropacket, not the number of bytes following the headers.

The Schedule header was made mandatory. The ports will be called "logical ports". It was agreed to combine the ID and Tag fields into a single field called "Key". The fields within the Schedule header will be re-organized to make the Key field contiguous. The Translation header was deleted, and the second micropacket will be zero-filled.

4.7 Scheduled transfers (pages 14-20)

All of 7, and its subclauses, was new. Don, with major help from James Hoffman, tried to base it on what was agreed to in the Albuquerque meeting. Don took editorial license and changed some things for consistency.

There was major re-wording to parts of 7.1. The text was not reviewed in detail; most of the time was spent on the table 5 summary.

The "First data" flag was moved to the msb, and a "last data" flag was added. A flag bit for "Data_ACK requested" was also added. It was also agreed to add commands for "Port_Teardown_ACK" and "Abort_ACK". Both Abort commands (from the Source, and from the Destination) will use the same op-code.

The open issues in the detailed text of 7.3 were addressed. It was agreed that the Originating Source would pick the VC to use, and pick it when it sent the data. Multiple VCs could be used.

A question was raised about how you terminate an unlimited size transfer, and it looks as if the "Last Data" flag bit should solve that case. It was agreed that the actions taken when a transfer is denied are outside the scope of the standard. It was also agreed that the Offset could be non-zero for other than the first block -- to cover the case where the offset is larger than the block size.

The B-num of the first block should be zero. The M-count should be decremented before each message, resulting in the last message having M-count = 0. Abort will be on a transfer basis rather than a block or message basis. Using the Abort does not obviate the need for a Port_Teardown.

5. HIPPI-6400-SC

5.1 Forward SD-3 Project Proposal

The draft SD-3 Project Proposal actions were deferred to the HNF-TC the following day.

5.2 Review recent document changes (Reference Rev 0.2)

Roger Ronald of E-Systems, the Technical Editor, noted that he had problems with fonts on his system. It was agreed to try to align the definitions, wording, and capitalization conventions between the SC and PH documents.

Most of the time was spent reviewing clause 5 and beyond. Many wording changes were suggested.

People found Figure 4 in Annex A confusing. It was suggested that there should be separate numbers for the hosts and ports on the interconnections. The loop-back on Switch B is also incorrect -- loop-back should be done by table changes, not physical cables.

6. Addressing

Michael McGowen of Essential Communications, who had been working on this, was not present due to a family emergency. The text in HIPPI-6400-SC Annex A.4 tries to capture much of what Michael was proposing.

7. Optical interconnect (3 pm - 6 pm Tuesday)

Stan Swirhun of Vixel had contacted potential optical interconnect vendors before the meeting, and also had them scheduled for 10 minutes presentations.

7.1 Brief overview of requirements

Don Tolmie presented an overview of HIPPI-6400-PH with the emphasis on the signaling interface, and a list of questions concerning an optical interface. He noted that the training sequence now has 20 ns, rather than 30 ns, up and down periods.

7.2 Presentations

John Crow [crow@watson.ibm.com, (914) 945-2624] of IBM described IBM's Parallel Optical Interconnect Technology (POI), with emphasis on the low cost Jitney program. The presentation showed a 20 line bus running at up to 500 Mbit/s per line. One bullet showed it as being cost competitive with copper. While this technology may not be applicable to the Gbit/s needed with an 8-bit wide HIPPI-6400, its low cost may make it worth including for 16-bit systems.

Sherman Zhu of NGK Optobahn [xzhu@optobahn.com, (310) 782-9500] described their parallel optical link. They will have a 10 line, 1 Gbit/s per line, system in 4Q96. It uses 1300 nm lasers with multimode fiber. Sherman stated that it is normally limited to 300 meters by fiber skew, but the skew compensation in HIPPI-6400 may allow distances of up to 1 km. The costs are about $100 per

Gbit/s per channel. 4, 8, and 12 channel system will be available in 3Q97.

Stan Swirhun [sswirhun@vixel.com, (303) 460-0700] of Vixel described a ganged 4 channel Fibre Channel compliant system running at 1.25 Gbit/s per channel. It used pigtailed 780 nm lasers, and mates with 62.5 micron fiber with 250 micron pitch. The cost is about $100 per Gbit/s per channel (including both transmitter and receiver).

Jerry Grula [rxse40@email.sps.mot.com, (602) 732-5346] of Motorola described their Optobus technology. Optobus I is available today, runs at up to 400 Mbit/s at distances up to 300 meters over 62.5 micron fiber. A unique feature is that it does not required a 4b/5b or other dc balanced coding scheme. Optobus II is planned for later '96, with rates of up to 800 Mbit/s, and distances of 100's of meters. Both use 850 nm VCSELs, and are 10 channels wide.

Steve Joiner [steve_joiner@sj.hp.com, (408) 435-6421] of Hewlett-Packard described their N-Plex, and participation in the POLO project. It is 10 channel duplex, with 1 Gbit/s per channel, and uses a push-pull connector with standard ribbon fiber.

Nick Lee [nalee@mmm.com, (612) 736-6924] of 3M Fiber Optics described their Inca process for low cost forming of fiber ribbon cables and integrated connectors. This work was part of the Jitney program. The follow-on Argus system (available in 1-3 years) is based on the low-cost Inca manufacturing process, uses 62.5 micron fiber with 250 micron pitch. A special ball and socket alignment is used, and the number of fibers is scalable.

Ron Kleckowski [klecko01@essw.alcoa.com, (864) 433-5332] of Alcoa Fujikura (AFC) described their HI-PER link push-pull connector system using an MT ferrule. This is used with the Optobus from Motorola. AFC is working with Bellcore to qualify it for telco environments, and with Fibre Channel. The connector is usable with multimode or single-mode fiber. (Note that coupling to VCSEL arrays is only possible with multimode today.) Connector loss is on the order of 1 dB.

Dan Brown [dan.brown@amp.com, (717) 986-7812] of AMP described their connector work done under POLO project. They are sampling the connector now, with production quantities being available 4Q96. It is a push-pull connector for 4-12 fibers, single-mode or multimode, with a loss of 1 dB max. AMP is also working on array transmitter and receiver modules.

Emile Sayegh [esayegh@wlgore.com, (512) 433-9114] of W.L. Gore described their Flex-Lite fiber optic technology covering 62.5, 50, and single-mode fiber. Skew matching is very good, but may not be needed with HIPPI-6400. The cable is a proven technology that has been available for several years, and has about a 1-2 week lead time. The cost is from $0.50 to $0.80 per meter for 12 conductor cable. It mates with the Berg MAC connector.

Ed Cady [EdCady@aol.com, (503) 359-4556] of Berg Electronics described their MACII connector. It supports 2-36 fibers, and is field installable. Silicon ferrules are available for harsh environments, Metral for office environments. A new MiniMAC connector is 1/2 the size. These are high-volume parts, previously only available to AT&T.

Don Knasel [dknasel_conec@msn.com, (704) 323-8883] of US Connector said that the MTP will be an ISO standard in 1996. There are more than 5 million ferrules in use today, and more going out today than any other multi-fiber ferrule. They cost on the order of $1 - $10 per fiber.

[Some of the presenters handed out copies of their presentations, others did not. Don Tolmie [det@lanl.gov, (505) 667-5502] has hard copies of most of the presentations, and is willing to send copies to anyone who asks - but realize that without the verbal presentation the slides may be more confusing than useful. It may be better to contact the presenter directly through the e-mail or phone number given for each presenter.]

7.3 Work planning

After the presentations a few items were listed on an overhead foil to see where we go from here. Most systems seemed to be pointing towards a 12-wide fiber cable, each fiber at 1 Gbit/s, for use with a HIPPI-6400 8-bit system. Distance is on the order of 200 - 300 meters. Other factors that need to be considered included:
- When available
- Cost
- Power
- Packaging - Low voltage PECL ?
- Eye Safety
- Footprint

Stan Swirhun strongly urged that we start from the FC-0 optical specifications. The optical component

people also preferred the 8b/10b as opposed to the 4b/5b for its shorter run lengths and narrower frequency band.

For now the HIPPI-6400 optical group will continue meeting in only the even months in conjunction with Fibre Channel. It was suggested that if we want to meet in the odd months that we co-locate it with X3T10 since many of the people will also be attending those meetings.

8. Copper interconnect (6 pm - 9 pm Tuesday)

Henry Brandt of IBM had contacted potential copper interconnect vendors before the meeting, and had them scheduled for presentations.

8.1 Brief overview of requirements

Don Tolmie again presented his overview of HIPPI-6400-PH with the emphasis on the signaling interface, and a list of questions concerning a copper interface.

8.2 Presentations

Steve Forman [no e-mail address given, (717) 730-4711] of Berg Electronics described their Micropax cable assembly. It is a small double-row, 100-position, latching connector aimed at high-end cables. Active components can be installed in the shell for termination. It is not currently in any other standard, but has been used in some SCI based implementations.

Craig Theorin [ctheorin@wlgore.com, (302) 368-2575] described some Gore products, and passed around some samples. He said that the copper products are much cheaper than optical. They are doing 1 Gbit/s over 30 meters for Fibre Channel. The sweet spot for minimum loss is 75 ohms (single ended) or 150 ohms differential. He showed a diagram of a 4 conductor cable with an overall shield that acted like two separate twinax cables due to the balanced nature of the wire in the cable. It resulted in a smaller overall diameter, but is also more difficult to terminate. Multiples of this quad cable are then combined for an overall cable. He suggested that we strongly consider adding Vcc and ground pins to power an optical extender or active terminators.

Michael Leib [mleib@interserv.com, (215) 426-9105] of Technitrol described some of their active terminators that extend the distance considerably by conditioning the line. The active terminators also allow the use of smaller wire size, decreasing the cable's outside diameter and making it more flexible.

[Some of the presenters handed out copies of their presentations, others did not. Don Tolmie [det@lanl.gov, (505) 667-5502] has hard copies of the presentations, and is willing to send copies to anyone who asks - but realize that without the verbal presentation the slides may be more confusing than useful. It may be better to contact the presenter directly through the e-mail or phone number given for each presenter.]

8.3 Work planning

After the presentations some items were listed on an overhead foil to try to set a direction for future work on the copper interface. The foil listed the following items:

- 22 wide @ 500 Mbit/s
- Distance = 10, 25, 50 meters
- Cable O.D. ≤ 0.6"
- Bend Radius ≤ 6"
- Plenum rated
- Full-duplex in one connector/cable
- Footprint ≤ a single HIPPI-800 connector
- Impedance = 150 ohm differential
- AC coupled
- Equalizer is acceptable
- Include power pins for optical repeater
- Pass FCC Class A and CISPRA
- Electrical levels Low Voltage PECL (TBD)
- Nail down electrical levels by 7/1/96
- Specification available 10/96
- Parts in place 1Q97

An interim meeting to discuss copper issues will be held in conjunction with the already scheduled HIPPI-6400 interim meeting in Mountain View, CA, at the SGI facility. The copper meeting will be from 2pm - 9pm, Thursday, July 11, 1996. Don Tolmie will send out a meeting announcement.

9. Other "Open Issues" not covered yet

No other open issues were discussed due to lack of time.

10. Future meeting schedule

10.1 July 10-11, Mountain View, CA

Wednesday, July 10 -
1 PM - 9 PM — HIPPI-6400
Thursday, July 11 -
8 AM - 2 PM — HIPPI-6400
2 PM - 9 PM — HIPPI-6400 copper
The location is on the Silicon Graphics Inc. campus. Hotels in the Mountain View and Palo Alto area are convenient. Greg Chesson and Silicon Graphics are the host. (See the meeting announcement on the web page for details and directions to the meeting room.)

10.2 August 5-6, 1996, Honolulu, HI

During the X3T11 August plenary week , the following HIPPI meetings are scheduled:
Monday, August 5 -
9 AM - 1 PM — Fibre Channel, HIPPI, & IPI tutorial
1 PM - 9 PM — HIPPI-6400
Tuesday, August 6 -
8 AM - 9 AM — HIPPI-6400 Optical background
9 AM - 10 AM — HNF Plenary
10 AM - 3 PM — HIPPI-TC General and -6400
3 PM - 6 PM — HIPPI-6400 Optical
6 PM - 9 PM — HIPPI-6400 Copper
The location is the Ala Moana Hotel, 410 Atkinson Drive, Honolulu, Hawaii 96814-4722, phone (808) 955-4811, Fax (808) 944-2974. The rate varies from $110 to $142, and the group name when making reservations is ANSI/X3T11/Hitachi. Paul Boulay and Hitachi are the host.

11. Review action items

All of the following action items apply to HIPPI-6400-PH unless otherwise noted.

1. Stan Swirhun, and others, to consider problems with FRAME signal frequency in optical implementations.
2. Greg Chesson to provide Don Tolmie with the parallel CRC equations to be added as an annex.
3. James Hoffman to verify CRC error protection results.
4. Roger Ronald to define admin micropacket contents and requirements and present to e-mail.
5. Greg Chesson and SGI to check to see if it is OK to include the Header micropacket in the ECRC calculation.
6. Greg Chesson, and James Hoffman, to check the low frequency limit of the 4b/5b code.
7. Greg Chesson and SGI to specify the order that bits are fed into the LCRC calculation.
8. Greg Chesson and SGI to provide text on what actions occur as a result of a Shutdown.
9. Greg Chesson and SGI to check the initial pattern for Reset operations and the need for the 10 second line-charge time.
10. Greg Chesson and SGI to see if it is OK to remove the 10 second line-charging delay during a Reset operation.
11. Greg Chesson and SGI to review the error conditions in 9.1. Check the grouping, ordering, names, and field sizes.
12. Greg Chesson and SGI to review the Scheduled transfers in clause 7 with special attention to Bufx.
13. Greg Chesson to provide ARP text for inclusion in HIPPI-6400-SC.
14. Greg Chesson to draft initial text for bridging.
15. Don Tolmie to update HIPPI-6400-PH Rev 0.25 with the changes agreed to at the Santa Fe meeting.
16. Roger Ronald to update HIPPI-6400-SC Rev 0.2 with the changes agreed to at the Santa Fe meeting.

12. Adjournment

The meeting adjourned at 9pm on Tuesday evening after an intense and fruitful two days.

Attendees: (at main HIPPI-6400 meeting)

Charles Brill	AMP
Daniel Brown	AMP
Sheldon Kolansky	Digital Equipment Corp
Bob Pearson	Essential Communications
Robert Clarkson	E-Systems
Craig Davidson	E-Systems
Richard Ellison	E-Systems
Roger Ronald	E-Systems
Francois Gaullier	Hewlett-Packard
Greg Huff	Hewlett-Packard
Henry Brandt	IBM
John Crow	IBM
Al Widmer	IBM
Chris Olson	Lockheed Martin
James Hoffman	Los Alamos National Lab
Wally St.John	Los Alamos National Lab
Don Tolmie	Los Alamos National Lab
Joe Parker	Optivision
Greg Chesson	Silicon Graphics

Attendees : (at HIPPI-6400 copper meeting)

Michael Fogg	AMP
Ed Cady	Berg Electronics
John Ellis	Berg
Steve Foreman	Berg Electronics
Michael Kary	Cable Design Tech
Sheldon Kolansky	Digital Equipment Corp
John Gibbon	Essential Communications
Craig Davidson	E-Systems
Richard Ellison	E-Systems
Roger Ronald	E-Systems
Henry Brandt	IBM
Gene Dornhoff	Los Alamos National Lab
James Hoffman	Los Alamos National Lab
Wally St.John	Los Alamos National Lab
Don Tolmie	Los Alamos National Lab
Brian Harvie	Madison Cable
Joe Parker	Optivision
Greg Chesson	Silicon Graphics
Michael Leib	Technitrol
Craig Theorin	W.L. Gore

Attendees: (at HIPPI-6400 optical meeting)

Michael Griffin	3M
Nicholas Lee	3M Fiber Optics
Tad Szostak	3M
Ron Kleckowski	AFL
Mackie Shiflett	AFL
Bob Atkinson	AMP
Charles Brill	AMP
Dan Brown	AMP
Michael Wingard	Amphenol Interconnect
Ed Cady	Berg Electronics
Robert Hooley	Berg
Carol McGill	Corning
Sheldon Kolansky	Digital Equipment Corp
John Gibbon	Essential Communications
Robert Clarkson	E-Systems
Craig Davidson	E-Systems
Richard Ellison	E-Systems
Roger Ronald	E-Systems
Haluk Aytac	Hewlett-Packard
Francois Gaullier	Hewlett-Packard
Greg Huff	Hewlett-Packard
Steve Joiner	Hewlett-Packard
Dan Rausch	Hewlett-Packard
Christie Rice	Honeywell
Henry Brandt	IBM
John Crow	IBM
Jonathan Thatcher	IBM
Al Widmer	IBM
Chris Olson	Lockheed Martin
James Hoffman	Los Alamos National Lab
Wally St.John	Los Alamos National Lab
Don Tolmie	Los Alamos National Lab
Virginia Haydu	Mitre
Jerry Grula	Motorola
Yasuo Sasaki	NTTI
Joe Parker	Optivision
Sherman Zhu	Optobahn
Todd Hudson	Siecor
Dons Pietsch	Siemens Fiber Optics
Klaus Schulz	Siemens Fiber Optics
Schelto van Doorn	Siemens
Greg Chesson	Silicon Graphics
Michael Leib	Technitrol
Don Knasel	US Connector
Stan Swirhun	Vixel Corp
Emile Sayegh	W.L. Gore
Craig Theorin	W.L. Gore